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Influence of Pellicle on 22 nm Pattern in Extreme Ultra-Violet Lithography

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INTRODUCTION

- Extreme ultraviolet lithography (EUVL) will be a very important technology to make smaller patterns below 22 nm. Recently, there are a lot of researches on the use of pellicle in EUVL. Pellicle has been used in optical lithography to protect printability by the contamination on the mask. EUVL process is totally different from conventional optical lithography and most materials would absorb EUV light unlike other optical pellicles. Up to now, there are two EUV pellicle structures; silicon membrane on wire mesh and on honeycomb. And many people think we need a EUV pellicle to protect the mask from the defect and contamination in EUVL.
- In this paper, the influences on the EUV pattern due to pellicle were studied. We studied the differences of transmission and reflection with and without the pellicle on the EUV mask for different EUV pellicle materials.
- Si and Ru for EUV pellicle were also studied.
- Pellicle deformation and C deposited contamination effect to the pattern are tested for the possible EUV pellicle use.

Simulation Conditions, Pellicle Materials (Si, Ru)

❖ Reflectivity of pellicle

Simulator	S-litho		
Wavelength	13.5 nm		
Incident angle	6°		
Pellicle material		n	k
	Silicon	0.9990	0.0018
	Ruthenium	0.8863	0.0170
Pellicle thickness	20 nm		
Distance Between Multilayer and pellicle	4 mm		

Table 1. Simulation condition.

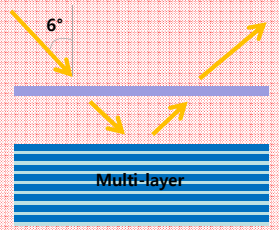


Figure 1. Structure of pellicle and multi-layer.

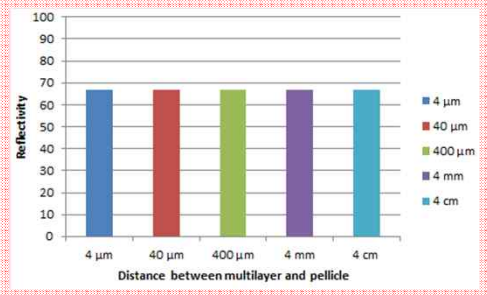


Figure 2. Two pass reflectivity with different gap between multilayer and pellicle with 20 nm Si pellicle thickness. Reflectivity does not change with different gaps as expected.

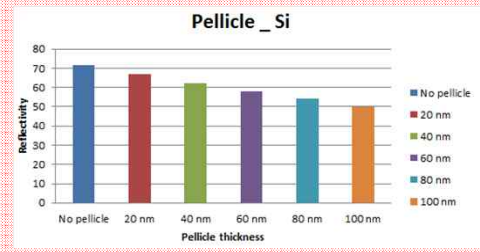


Figure 3. Reflectivity for different thicknesses of Si pellicle.

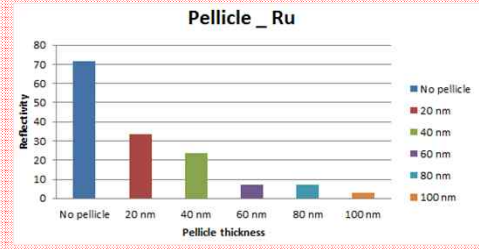


Figure 4. Reflectivity for different thicknesses of Ru pellicle.

Results

❖ Pellicle deformation

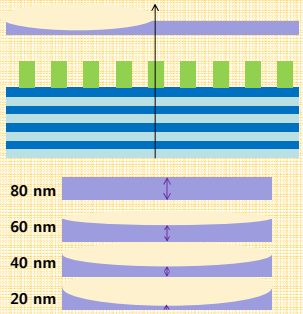


Figure 5. Deformation of Si pellicle. 3 cases of the deformation (60 nm, 40 nm, 20 nm).

Simulator	S-litho
Wavelength	13.5 nm
Incident angle	6°
CD	22 nm line & space
Pellicle thickness	80 nm
Gap between multilayer and pellicle	40 μm

Table 2. Simulation condition.

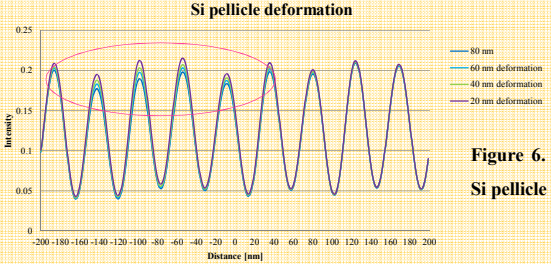
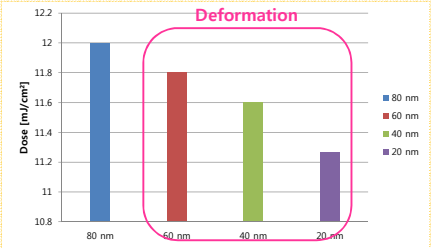


Figure 6. Aerial image of Si pellicle deformation.

Figure 7. Proper doses to make 22 nm pattern. When there is no deformation, 12 mJ/cm² is needed. However, because of pellicle deformation, pellicle thickness is thinner than 80 nm.



❖ Carbon contamination

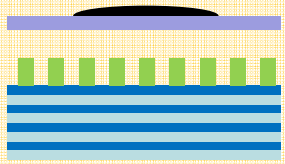


Figure 8. Carbon contamination on top of the Si pellicle.

Simulator	S-litho		
Wavelength	13.5 nm		
Incident angle	6°		
CD	22 nm line & space		
Pellicle material		n	k
	Carbon	0.9615	0.0069
Pellicle thickness	20 nm		
Gap between multilayer and pellicle	40 μm		

Table 3. Simulation condition.

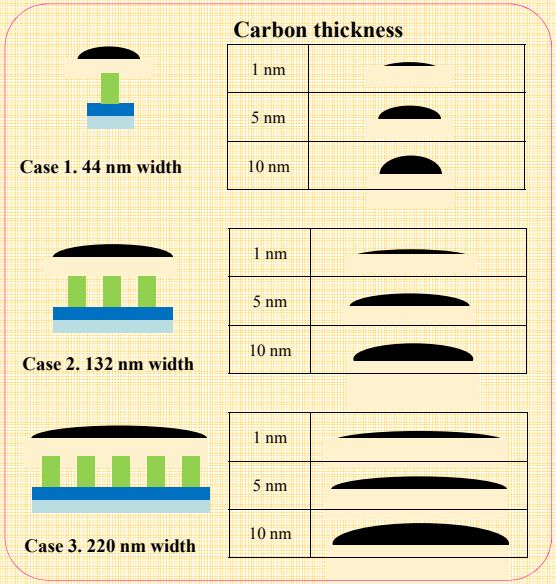


Figure 9. Simulated C contamination.

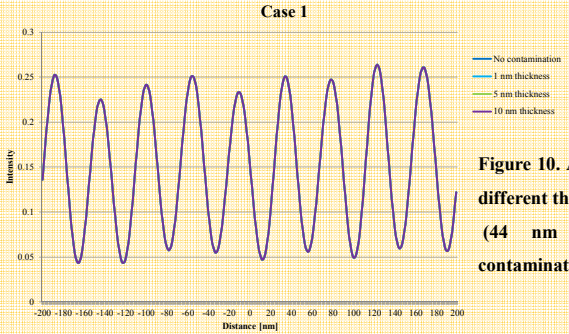


Figure 10. Aerial images for different thickness of case 1 (44 nm width carbon contamination).

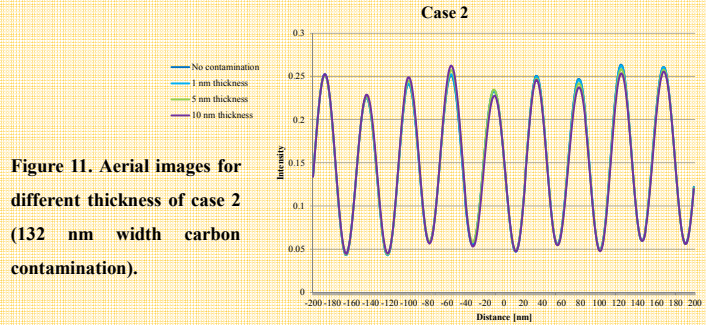


Figure 11. Aerial images for different thickness of case 2 (132 nm width carbon contamination).

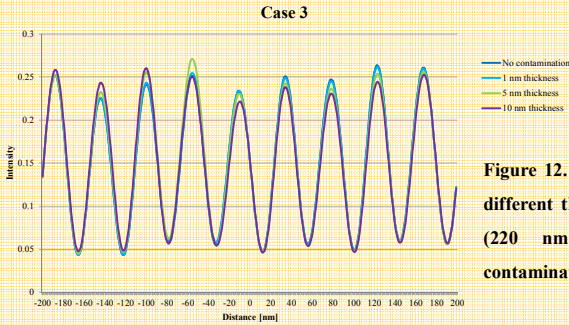


Figure 12. Aerial images for different thickness of case 3 (220 nm width carbon contamination).

Conclusions

- ❖ Gap between multilayer and pellicle does not change the reflectivity as expected.
- ❖ Deformation does not particularly influence on the pattern.
- ❖ Silicon is better than ruthenium for better transmission of pellicle in EUVL.
- ❖ Carbon contamination on top of the pellicle gives minimal effect to the pattern.
- ❖ Overall, Si thin film pellicle works and can protect the mask without a noticeable impact to the pattern.

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